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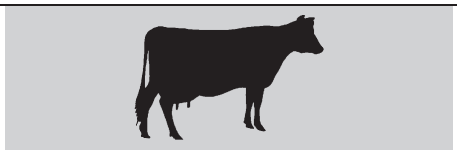

Milk yield and composition of lactating dairy cows fed diets supplemented with a probiotic extract

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ABSTRACT

Thirty-six lactating Holstein cows from the Dairy Research Center at the University of Georgia Tifton Campus were used in a 10-wk randomized-design trial to determine the effects of feeding a nonviable probiotic extract (PD; ProDairy, Donaghys Industries Ltd., Christchurch, New Zealand) on DMI, milk yield, and milk composition. During the first 2 wk of the trial, all cows were fed the control diet, and data collected were used as a covariate in the statistical analysis. At the end of wk 2, cows were assigned randomly to 1 of 2 treatments: 0 (CONT) or 10 mL/d of PD per cow for the following 8 wk. A basal diet was fed to cows once daily behind Calan gates as a TMR in amounts to provide at least 5% refusal. The probiotic extract was added to the TMR and mixed for 10 min before feeding. No differences were observed in DMI between treatments, which averaged 25.3 and 25.6 kg/d for CONT and PD, respectively. Yields of milk ($P = 0.001$), protein ($P = 0.05$), and solids-not-fat ($P = 0.002$) were greater for cows fed diets supplemented with PD compared with CONT. Interactions of treatment and week were observed for each variable because the difference between PD and CONT increased as the trial progressed. Milk urea nitrogen concentrations tended to be reduced ($P = 0.10$) for PD compared with CONT. No differences were observed among treatments in concentration of milk components or change in BW or BCS. The probiotic extract used in the trial supported greater yield of milk, protein, and solids-not-fat apparently through improved utilization of nutrients consumed.

Key words: probiotic extract, milk yield, milk composition

INTRODUCTION

"Probiotics" or "direct-fed microbials" are defined as cultures of live microorganisms that have health benefits to the host (Sanders, 2008; Ezema, 2013). Nonviable probiotics including cultural extracts, enzyme preparations, or combinations of these have also been reported to promote similar beneficial effects (Krehbiel et al., 2003; Sanders, 2008; Poppy et al., 2012). Use of these probiotics, live and nonviable, has been reported to improve ADG, feed efficiency, milk yield, and health when fed to cattle, presumably as a result of improved ruminal and intestinal microorganism populations (Krehbiel et al., 2003). Several modes of action have been proposed including stimulation of ruminal microbial growth, stabilization of ruminal pH, improved ruminal fermentation patterns, increased nutrient digestibility and flow of nutrients to the small intestine, improved nutrient retention, and reduced stress (Yoon and Stern, 1995; Krehbiel et al., 2003; Chiquette, 2009). Because dairy cattle consume large quantities of readily fermentable carbohydrates, which can reduce ruminal pH, the use of supplemental probiotics has been proposed as a means of moderating the rapid decline in or stabilizing pH by decreasing lactic acid production and increasing lactic acid utilization (Fulton et al., 1979).

Rossow et al. (2014) reported improved milk yield and ruminal pH and reduced blood ketone concentrations when a commercially produced probiotic extract produced from bacteria and yeasts was administered in water troughs. Data are lacking on the potential of this probiotic extract when applied to a TMR. The objective of this trial was to evaluate the effect of a supplemental nonviable probiotic extract on the milk yield and composition response of lactating dairy cows fed a TMR based on corn silage.

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Table 1. Ingredient composition of basal diet

Ingredient	% of DM
Corn silage	38.54
Alfalfa hay	8.12
Finely ground corn	10.14
Whole cottonseed	7.10
Brewers grains, wet	13.19
Soybean hulls	6.09
Citrus pulp	6.09
Molasses, dried	1.01
Soybean meal, 47.5% CP	3.04
Prolak[1]	3.55
Urea	0.30
Potassium carbonate	0.91
Sodium bicarbonate	0.81
Magnesium oxide	0.30
Potassium-magnesium-sulfate	0.10
Dicalcium phosphate	0.10
Salt	0.41
Availa-4[2]	0.04
Vitamin E, 44,050 IU/kg	0.02
Trace mineral–vitamins[3]	0.14

[1]H. J. Baker & Bro. Inc. (Westport, NJ).

[2]Zinpro Corp. (Eden Prairie, MN).

[3]Mineral–vitamin premix contained (DM basis) 26.1% Ca; 0.38% Mg; 1.76% S; 144 mg/kg Co; 9,523 mg/kg Cu; 1,465 mg/kg Fe; 842 mg/kg I; 28,617 mg/kg Mn; 220 mg/kg Se; 25,343 mg/kg Zn; 4,210,830 IU/kg vitamin A; 1,684,330 IU/kg vitamin D; and 21,045 IU/kg vitamin E.

MATERIALS AND METHODS

Thirty-six lactating Holstein cows (8 primiparous and 28 multiparous) were selected from the herd at the University of Georgia Tifton Campus for use in the 10-wk trial. All protocols were approved by the Institute of Animal Care and Use Committee of the University of Georgia. Before beginning the trial, all cows were trained to eat behind Calan doors (American Calan Inc., Northwood, NH). Cows were housed in a 4-row freestall barn equipped with 91-cm fans mounted over the feed alley and freestalls every 6.1 m. The fans were programmed to come on automatically when the temperature in the barn exceeded 23°C. The fans were fitted with high-pressure misters programmed to operate when the fans were running until the relative humidity exceeded 85%. Cows were provided access to an exercise lot once daily at approximately 0830 through 0900 h.

A basal diet (Table 1) was formulated to meet minimum NRC (2001) requirements and fed once daily as a TMR in amounts to provide at least 5% refusal. Feed was pushed up at least twice daily for each cow. During the 2-wk preliminary period, all cows were fed the control diet. At the end of wk 2, cows were randomly assigned to 1 of 2 treatments for the following 8 wk. At the beginning of the experimental period, cows averaged 183 ± 28 DIM, 33.7 ± 5.7 kg/d milk, 3.73 ± 0.61% fat, and 2.85 ± 0.20% protein. Treatments were 0 (**CONT**) or 10 mL/d of the probiotic extract (**PD**; ProDairy, Donaghys Industries Ltd., Christchurch, New Zealand) per cow. Cows assigned to PD were fed last to minimize any possible contamination of the CONT. The PD was sprayed onto the ingredients as ingredients were mixed (DataRanger, American Calan Inc.) and blended for 10 min before feeding. The amount of feed offered and refused was recorded daily. Samples of dietary ingredients and experimental diets were collected 3 times each week. Samples were dried at 55°C for 48 h to determine DM, ground to pass through a 6-mm screen (Thomas Scientific, Swedesboro, NJ), and composited by week within sample type. Diets were adjusted for changes in DM content of individual ingredients as necessary. Samples were ground to pass through a 1-mm screen before being analyzed for DM, ash, ether extract (AOAC International, 2000), ADF, and NDF (Van Soest et al., 1991).

Cows were milked twice daily at 0300 and 1500 h. Milk weights were recorded electronically (Alpro, DeLaval Inc., Kansas City, MO) at each milking, totaled each day, and averaged weekly. Milk samples were collected from 2 consecutive p.m. and a.m. milkings each week. Samples were shipped to Dairy One (Ithaca, NY) for analyses of fat, protein, lactose, solids-not-fat (**SNF**), and milk urea N (**MUN**) using a Foss 4000 equipped with an A filter (Foss North America, Eden Prairie, MN) as described by AOAC International (2000). Energy-corrected milk (**ECM**) was calculated as outlined by Tyrell and Reid (1965): ECM = (0.327 × kg of milk) + (12.95 × kg of fat) + (7.65 × kg of protein).

Body weights were recorded on 3 consecutive days at the end of the standardization period and end of wk 8 of the experimental period. To minimize variation, BW was recorded after the p.m. milking and before cows had access to feed or water. The BCS was recorded at the end of the preliminary period and during wk 4 and 8 according to Wildman et al. (1982) by 2 evaluators.

Intake, milk yield and composition, BW, and BCS data were subjected to analyses of covariance using PROC MIXED procedures of SAS (SAS Institute Inc., Cary, NC). Sums of squares were partitioned to covariate, treatment, week, and interaction of week and treatment. Cow within treatment was included as a random variable and week was considered a repeated measure. Changes in BW

Table 2. Chemical composition of experimental diets supplemented with (PD) or without (CONT) a probiotic extract

Item, % of DM	CONT	PD
DM, %	49.0 ± 3.6	48.1 ± 20.7
Ash	7.39 ± 0.37	7.35 ± 0.58
CP	18.40 ± 1.25	18.45 ± 0.93
NDF	36.45 ± 2.10	37.00 ± 2.61
ADF	19.15 ± 19.44	19.44 ± 1.66
Ether extract	4.00 ± 0.35	3.99 ± 0.56
NFC[1]	33.76 ± 1.57	32.21 ± 2.24

[1]Nonfiber carbohydrates (NFC) = 100 − (ash + CP + NDF + ether extract).

Table 3. Dry matter intake and milk yield and composition of lactating dairy cows fed diets without (CONT) or with (PD) probiotic extract

Item[1]	CONT	PD	SE	*P*-value
DMI, kg/d	25.3	25.6	0.9	0.79
Milk, kg/d	30.9	32.7	0.4	0.001
Fat, %	4.20	3.99	0.12	0.17
Fat, kg/d	1.20	1.20	0.04	0.89
Protein, %	2.93	2.89	0.02	0.16
Protein, kg/d	0.91	0.94	0.01	0.05
Lactose, %	4.60	4.78	0.10	0.20
Lactose, kg/d	1.42	1.56	0.04	0.03
SNF, %	8.37	8.38	0.02	0.70
SNF, kg/d	2.58	2.74	0.03	0.002
ECM, kg/d	33.8	34.8	0.6	0.25
Efficiency, ECM/DMI	1.34	1.36	0.05	0.09
MUN, mg/dL	15.44	15.03	0.25	0.10

[1]SNF = solids-not-fat; ECM = energy-corrected milk; MUN = milk urea nitrogen.

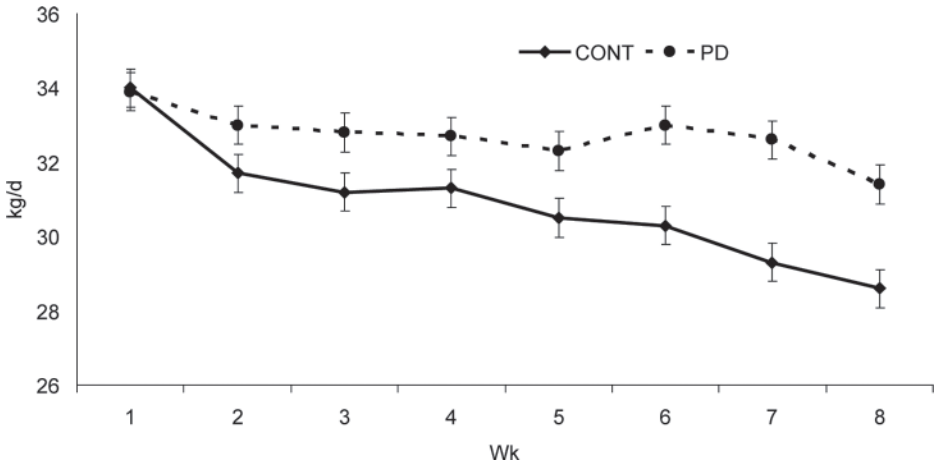

Figure 1. Interaction of week and treatment for milk yield of lactating cows fed diets without (CONT) or with (PD) probiotic extract ($P = 0.0007$); error bars represent SEM.

or BCS were subjected to ANOVA using PROC GLM procedures of SAS. Sums of squares were partitioned to covariate, cow, and treatment. Initial BW and BCS were included in the model as covariates. Significance was declared at $P < 0.05$ and trends when $P > 0.05$ and $P < 0.10$.

RESULTS AND DISCUSSION

The chemical composition of the experimental diets is outlined in Table 2. The diets contained similar concentrations of nutrients, which were consistent with expected formulated values.

No differences in DMI were observed among treatments (Table 3). Milk yield was higher ($P = 0.001$) for cows fed PD compared with CONT. An interaction of week and treatment ($P = 0.0007$) was observed because cows fed PD maintained milk yield throughout the 8-wk experimental period, whereas the milk yield of cows fed the CONT decreased so that the difference between treatments increased throughout the trial, especially after wk 5 (Figure 1).

No differences were observed in percentage of milk fat, protein, lactose, or SNF among treatments (Table 3). Yields of milk protein ($P = 0.05$) and SNF ($P = 0.002$) were highest for PD compared with CONT. An interaction of week and treatment was observed for yields of milk protein ($P = 0.009$, Figure 2) and SNF ($P = 0.02$, Figure 3), similar to that observed for milk yield. No differences were observed in yield of milk fat and lactose. An interaction of week and treatment ($P = 0.06$) was observed for ECM. Yield of ECM was similar during wk 1 through 5, but cows fed PD maintained higher ECM yield, whereas cows fed CONT decreased ECM yield after wk 5 (Figure 4). A trend ($P = 0.09$) was observed for a slight improvement in dairy efficiency (ECM/DMI) for PD compared with CONT. Concentration of MUN tended to be lower ($P = 0.10$) for cows fed PD compared with CONT.

Jenkins and Jenkins (2014) summarized the results of 10 trials in which

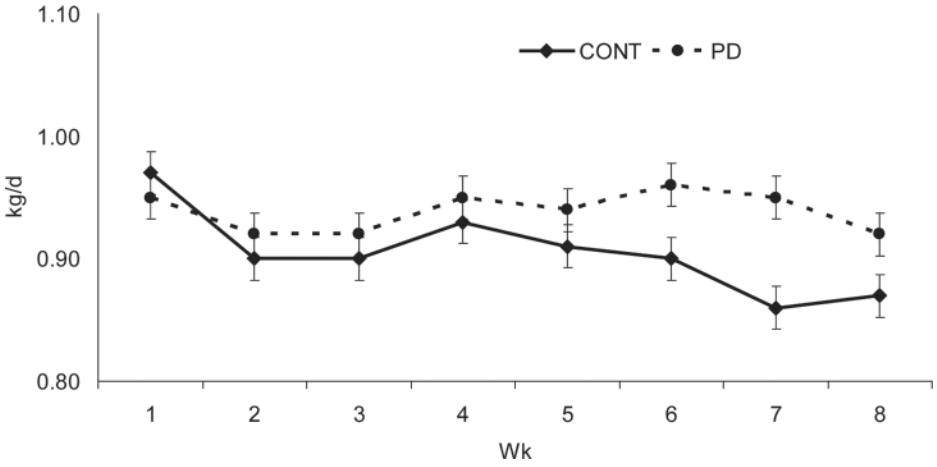

Figure 2. Interaction of week and treatment for milk protein yield of lactating cows fed diets without (CONT) or with (PD) probiotic extract ($P = 0.009$); error bars represent SEM.

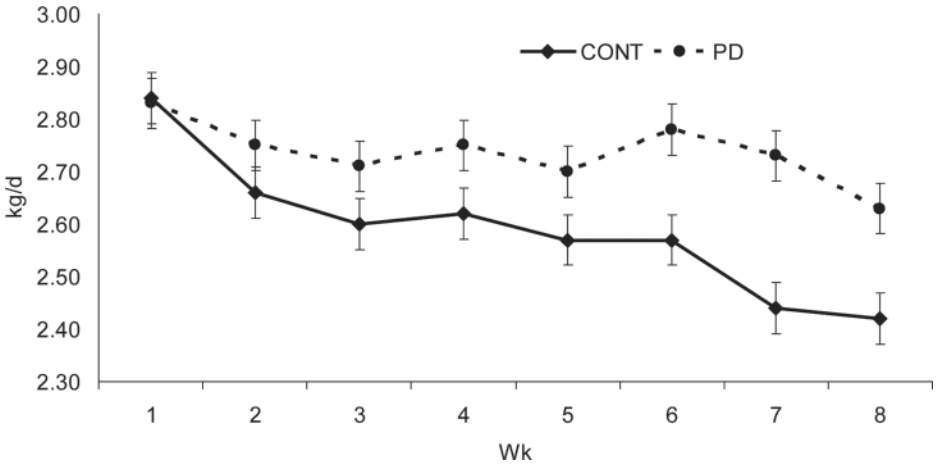

Figure 3. Interaction of week and treatment for milk solids-not-fat yield of lactating cows fed diets without (CONT) or with (PD) probiotic extract ($P = 0.02$); error bars represent SEM.

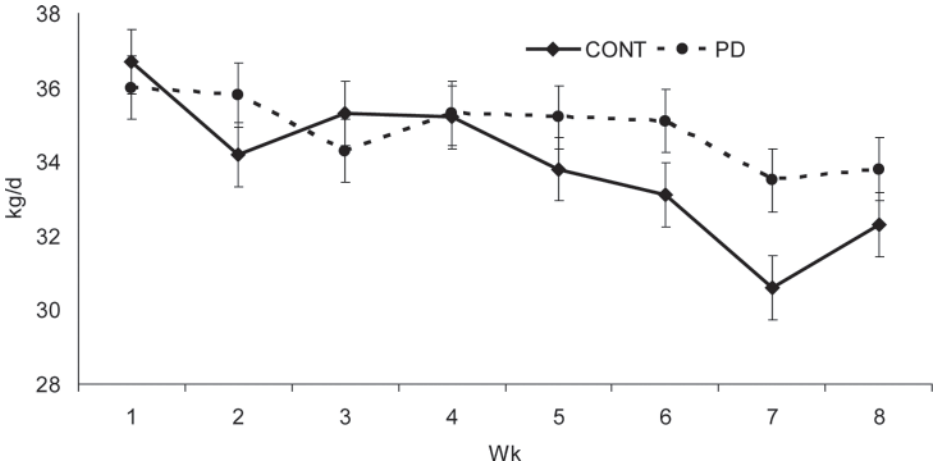

Figure 4. Interaction of week by treatment for energy-corrected milk of lactating Holstein cows fed diets without (CONT) or with (PD) probiotic extract ($P = 0.06$); error bars represent SEM.

PD was offered to lactating dairy cows by daily drench, water trough, or TMR and reported improvements in yield of milk solids. Rossow et al. (2014) reported greater milk yield but slightly lower milk protein yield for cows fed PD. No differences were observed in yield of milk fat or percentages of milk fat and protein. These researchers measured higher ruminal pH and lower concentrations of blood BHBA when PD was administered through water troughs. The improvement in ruminal pH would support improved ruminal fermentation providing additional nutrients in support of milk synthesis. The lower BHBA concentrations suggest improved nutrient balance (Rossow et al., 2014). No differences were reported in DMI, yields of milk or components, MUN or ruminal ammonia or pH by Allen and Ying (2012) when supplemental *Saccharomyces cerevisiae* fermentation product was fed to ruminally and duodenally cannulated cows. In a meta-analysis of 61 research publications, Poppy et al. (2012) reported increased yield of milk, fat, and protein when cows were fed diets supplemented with *Saccharomyces cerevisiae* fermentation product.

Initial BW and BCS were similar among treatments and averaged 690.8 kg and 3.20, respectively. During the 8-wk experimental period, there were no differences in change of BW ($P = 0.20$) or BCS ($P = 0.74$) for cows fed CONT (36.8 kg and 0.07) or PD (15.9 kg and 0.05). This is consistent with the reports of Rossow et al. (2014) and Jenkins and Jenkins (2014).

Results of this trial indicate that including PD into the TMR fed to lactating dairy cows supports improved yields of milk, protein, and SNF. This trial was not designed to monitor changes in ruminal fermentation; however, the trend for decreased MUN and corresponding increase in yields of milk and protein suggest improved ruminal fermentation providing additional energy, microbial protein, or both, which was used to support increased synthesis of milk and milk protein by the mammary gland. These changes occurred with-

out any change in nutrient intake and appeared during wk 2 after inclusion into the diet.

IMPLICATIONS

Performance of lactating dairy cows was improved when they were fed a nonviable probiotic extract. The improvements increased throughout the trial, suggesting that the mode of action was to improve ruminal fermentation and utilization of dietary N. These results along with other research with this product warrant additional research to validate its potential for improving performance in longer trials and determine its effects on ruminal fermentation.

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